State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

JUVENILE SPRING-RUN CHINOOK SALMON EMERGENCE, REARING AND OUTMIGRATION PATTERNS IN DEER AND MILL CREEKS, TEHAMA COUNTY, FOR THE 1998 BROOD YEAR

SPORT FISH RESTORATION ANNUAL PROGRESS REPORT

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Calendar Date to Julian Week Conversion

Oct 04-10, 1998	40	Apr 25-May 01, 1999	17	Nov 14-20, 1999	46
Oct 11-17, 1998	41	May 02-08, 1999	18	Nov 21-27, 1999	47
Oct 18-24, 1998	42	May 09-May 15, 1999	19	Nov 28-Dec 04, 1999	48
Oct 25-31, 1998	43	May 16-22, 1999	20	Dec 05-11, 1999	49
Nov 01-07, 1998	44	May 23-29, 1999	21	Dec 12-18, 1999	50
Nov 08-14, 1998	45	May 30-Jun 05, 1999	22	Dec 19-25, 1999	51
Nov 15-21, 1998	46	Jun 06-12, 1999	23	Dec 26-Jan 01, 2000	52
Nov 22-28, 1998	47	Jun 13-19, 1999	24	Jan 02-08, 2000	1
Nov 29-Dec 05, 1998	48	Jun 20-26, 1999	25	Jan 09-15, 2000	2
Dec 06-12, 1998	49	Jun 27-Jul 03, 1999	26	Jan 16-22, 2000	3
Dec 13-19, 1998	50	Jul 04-10, 1999	27	Jan 23-29, 2000	4
Dec 20-26, 1998	51	Jul 11-17, 1999	28	Jan 30-Feb 05, 2000	5
Dec 27-Jan 02, 1999	52	Jul 18-24, 1999	29	Feb 06-Feb 12, 2000	6
Jan 03-09, 1999	1	Jul 25-31, 1999	30	Feb 13-19, 2000	7
Jan 10-16, 1999	2	Aug 01-07, 1999	31	Feb 20-26, 2000	8
Jan 17-23, 1999	3	Aug 08-14, 1999	32	Feb 27-Mar 04, 2000	9
Jan 24-30, 1999	4	Aug 15-21, 1999	33	Mar 05-11, 2000	10
Jan 31-Feb 06, 1999	5	Aug 22-28, 1999	34	Mar 12-18, 2000	11
Feb 07-13, 1999	6	Aug 29-Sep 04, 1999	35	Mar 19-25, 2000	12
Feb 14-20, 1999	7	Sep 05-11, 1999	36	Mar 26-Apr 01, 2000	13
Feb 21-27, 1999	8	Sep 12-18, 1999	37	Apr 02-08, 2000	14
Feb 28-Mar 06, 1999	9	Sep 19-25, 1999	38	Apr 09-15, 2000	15
Mar 07-13, 1999	10	Sep 26-Oct 02, 1999	39	Apr 16-22, 2000	16
Mar 14-20, 1999	11	Oct 03-09, 1999	40	Apr 23-29, 2000	17
Mar 21-27, 1999	12	Oct 10-16, 1999	41	Apr 30-May 06, 2000	18
Mar 28-Apr 03, 1999	13	Oct 17-23, 1999	42	May 07-13, 2000	19
Apr 04-10, 1999	14	Oct 24-30, 1999	43	May 14-20, 2000	20
Apr 11-17, 1999	15	Oct 31-Nov 06, 1999	44	May 21-27, 2000	21
Apr 18-24, 1999	16	Nov 07-13, 1999	45	May 28-31, 2000	22

INTRODUCTION

This annual brood year (BY) report investigates the life-history of spring-run Chinook salmon (SRCS), (*Oncorhynchus* *tshawtscha*), spawning in Mill and Deer creeks, Tehama County, California for 1998. This includes monitoring: holding and spawning distribution of adult SRCS returning in 1998, juvenile SRCS rearing studies in 1998 and 1999, and yearling SRCS emigration in 1999 and 2000. Also, included in this life-history investigation are the physical parameters of water flow and temperature during critical periods of adult and juvenile SRCS development.

SRCS once occupied the headwaters of most major river systems on California's Central Valley. Most of this former spring-run habitat has been eliminated by water development and dams that prevent adult salmon access to head water areas (CDFG, 1998). Present day range and distribution of spring-run salmon is restricted to a few tributaries in the Sacramento River System. Due to the declining population levels, loss of historical habitat and concerns over hybridization due to a lack of spatial separation with fall run in the Sacramento River and Feather rivers, tributary SRCS were listed as threatened under CESA and FESA in 1998. Mill, Deer and Butte creeks consistently support small numbers of spawning populations of spring-run chinook Even prior to water development, stream conditions in these remnant streams may have been marginal when compared to stream conditions historically occurring in the headwaters of the San Joaquin, Little Sacramento, McCloud and Pit rivers. One of the purposes of this life history investigation is to monitor these stream conditions for all stages of SRCS and identify and remedy any factors limiting survival.

This research is funded through the Federal Sport Fish Restoration Act. This 98 BY report is the sixth annual "Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigrant Report" for Mill and Deer Creeks. [1]

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[1] This program received financial assistance through the Federal Aid in Sport Fish Restoration Act. The U.S. Department of the Interior prohibits discrimination on the basis of race, color, national origin, age, sex, or disability. If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information, please write to:

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METHODS

Adult SRCS holding distribution surveys are made by underwater snorkel count in August, prior to the onset of spawning. Spawning surveys are made by walking the creek and recording carcasses, live salmon and redds. These surveys are done in September and October. Tissues are collected from carcasses for genetic analysis with the objective of locating a distinct marker for the spring run of chinook salmon. Mill Creek again remained too turbid in 1998 to monitor the adult salmon holding distribution therefore only spawning distribution is documented. Both holding and spawning distribution of adult SRCS are documented for Deer Creek.

Areas where a high concentration of spawning is known to occur are sampled weekly at the onset of predicted fry emergence to determine relative growth of salmon fry and to predict the occurrence of a fry or yearling outmigration pattern for each brood year. A backpack electro shocking unit and a 10' x 4' x □” beach seine is used to capture fish for length and weight measurements. In the fall and early winter months, 5' rotary screw traps are fished near each creeks confluence with the Sacrament River to monitor outmigration of SRCS yearlings on a real-time basis. These data are used in predicting the occurrence of SRCS yearlings in the Sacramento-San Joaquin Delta.

Water temperature records are collected by the Department of Water Resources (DWR), Northern District Office Water Quality Branch. Onset Temperature Recorders are used to collect hourly data in Mill Creek at: the mouth, Hwy-99 Bridge, USGS gauge, mouth of Little Mill Creek, Black Rock, Hole-In-the-Ground Camp, and Hwy-36 Bridge. In Deer Creek, recorders are installed at: the mouth, Hwy-99 Bridge, Upper Diversion dam, Apperson Cow Camp, Ponderosa Way, A-Line Bridge, and Upper Falls. These records are used to document adult migration, rearing, and spawning temperatures, and juvenile egg incubation, emergence, rearing and emigration temperatures.

Water flow records are taken from DWR's California Data Exchange Centers (CDEC) web site: www.cdec.water.ca.gov. All flows are recorded as daily average means for the purposes of this report. This data is preliminary and subject to change. In order to determine migration flow needs for migrating adult and juvenile salmon, flow readings are taken upstream of irrigation diversions (CDEC station MLM (Mill Los Molinos), and DCV (Deer Creek Vina)), and downstream of irrigation diversions (CDEC station DVD (Deer Creek Vina)).

All sampling locations used for these SRCS life history investigations are shown in Appendix, Figure 1 (Mill Creek) and Appendix, Figure 2 (Deer Creek).

RESULTS AND DISCUSSION

Conditions for Adult SRCS Migration

In order to assess real-time water flow and temperature needs for adult SRCS immigration, monitoring of these conditions is necessary downstream of water diversion points from March through early July. In Mill Creek, flow records for this time period in 1998 are only available at the MLM station, which is located upstream of water diversion points. (In January 1999, a flow gauge, MCH (Mill Creek Highway), will be installed downstream from all diversion points and adult salmon migration flows can be monitored on a real-time basis.) Appendix, Figure 3 shows the natural average daily flows in Mill Creek in relation to the migration timing of adult SRCS. This migration timing data came from a counting station operated at Clough Dam from 1953 thru 1964. Using this generalized migration timing, 80% of adult spring-run salmon migrate between the time periods of 6 May and 23 June in Mill Creek. Natural flows averaged 800 cfs during this time period in the spring of 1998. The minimum flow recorded was 483 cfs and the maximum flow was 1,666 cfs. Although flow records below the water diversions are not available for this time period, the maximum amount of flow that can be diverted from lower Mill Creek is 203 cfs. Assuming this maximum amount was diverted, flows still remained above 280 cfs during the peak periods of adult salmon migration. Flow does not appear to have limited adult SRCS migration into Mill Creek in the spring of 1998.

Water temperatures at the mouth of Mill Creek are also not available for the spring of 1998. Appendix, Figure 4 displays the water temperature records in Mill Creek taken at the USGS gauge, upstream of diversion points. The average daily water temperature during the peak period of adult salmon migration was 54 EF. The minimum and maximum daily average water temperature was 49EF and 58EF, respectively. In the absence of temperature records at the mouth of Mill Creek, it is unknown whether water temperatures remained within the normal tolerance range for adult salmon migrating into Mill Creek. For adult chinook salmon in the Sacramento River, the maximum temperature for successful upstream migration appears to be less than 65EF (Boles, 1988). The upstream migration of adult chinook salmon from the Delta to the San Joaquin River has been prevented by water temperatures above 70EF. Upstream migration was resumed when water temperatures cooled to 65EF (Hallock et al, 1970). SRCS may be locally adapted to brief periods of elevated water temperatures in order to reach their natal holding and spawning areas. In the Lower Klamath River system water temperatures as high as 76EF apparently have no effect on upstream migration of adult salmon (Dunhan, 1968), although sustained water temperatures in excess of 80EF are lethal for adult salmon (Cramer and Hammack 1952). Continued monitoring of flows and water temperatures during periods of adult salmon migration into Mill Creek will facilitate real-time flow and temperature requirements for adult salmon migration.

In Deer Creek, flow records for the period of adult salmon migration are available for CDEC station DCV, located upstream of water diversion points. The downstream flow gauge, DVD, did not record flows from 16 March to 17 July. To estimate attraction flows for salmon migrating into Deer Creek during periods of no record, average daily diversion rates were calculated for the dates on record from 1 March to 15 July. The average daily diversion rate was 295 cfs. Appendix, Figure 5 shows the natural average daily flow (pre-diversions) and the estimated average daily attraction flow (post-diversion) in Deer Creek in relation to peak periods of salmon migration. (In Deer Creek, real-time migration timing has not been documented; therefore average migration timing of Mill Creek spring run is used. Salmon may migrate into Deer Creek earlier than Mill Creek). During peak periods of salmon migration, natural flows in

Deer Creek averaged 813 cfs. The minimum and maximum natural flow recorded were 452 cfs and 2,056 cfs respectively. Assuming that the average amount of water diverted during this time period is 295 cfs, the estimated attraction flow into Deer Creek averaged 510 cfs. The minimum and maximum estimated attraction flow is 119 cfs and 1,761 cfs, respectively. Attraction flows did not decrease below 100 cfs until 26 June. By this time over 95% of the run is estimated to have migrated into Deer Creek. Attraction flow does not appear to have limited SRCS migration into Deer Creek in 1998.

Deer Creek water temperatures were recorded near the gauging station at the canyon mouth and at the Hwy-99 Bridge (Appendix, Figure 6). The gauging station is upstream of water diversions and the Hwy-99 Bridge is downstream of diversion points. (Water temperatures at the mouth of Deer Creek were not recorded until after 24 June, therefore Hwy-99 temperature records will be used to represent temperatures during adult salmon migration. The average temperature difference between the mouth and Hwy-99 between 27 June and 15 July 1998 was 0.8EF.) The average daily water temperatures at Hwy-99 Bridge during the peak migration periods 6 May thru 23 June was 58EF. The maximum average daily temperature was 67EF. For this same time period the average daily temperature at the gauging station was 55EF with a maximum average daily temperature of 63EF. Assuming that adult salmon migration is similar in both Mill and Deer creeks, 87% of salmon had migrated into Deer Creek prior to the daily average water temperatures reaching 65EF. Ninety-eight percent of migration occurred prior to temperatures reaching 70EF. Water temperatures remained within the range of normal tolerance limits for adult SRCS migrating into Deer Creek in 1998. Continued monitoring of flows and water temperatures during periods of adult migration into Deer Creek will facilitate real-time flow and temperature requirements for adult salmon migration. Knowing the actual timing of SRCS migration into Deer Creek would assist the Department in negotiating for additional flows during critical periods of migration.

1998 Adult SRCS Population Counts and Spawning Surveys in Mill and Deer Creeks.

______After the breeching of Clough Dam on Mill Creek in 1997, and subsequently investigating alternative methods of estimating adult spring-run populations, it was determined that spawner redd counts were the most feasible method of estimating the spring-run spawner escapement in Mill Creek (Harvey Arrison, 1997). Actual redd counts are expanded to a population estimate by assuming each female salmon constructs one redd and the female to male spawner ratio is 1:1. Using expanded redd counts, an estimated 424 adult SRCS spawned in Mill Creek in 1998 (Harvey Arrison, 1998a). In order to improve the accuracy of expanding redd counts to a population estimate, the actual ratio of females per redd will be investigated in future surveys. In addition to the redd counts, 26 carcasses were observed.

In Deer Creek a total of 1,879 adult SRCS salmon were counted in 1998. This count was derived from a snorkel survey of the adult SRCS holding habitat (Harvey Arrison, 1998b). A spawning census survey in the fall of 1998 counted a total of 793 redds and 137 carcasses (USFS, 1998).

Sex and Age Structure of the Population

All salmon carcasses encountered during spawning surveys in Mill and Deer creeks were sexed and measured to the nearest centimeter fork length (cm, FL). To increase the sample size, Mill and Deer creek data was combined. (This is assuming that the Mill and Deer creek populations have similar age structures.) A total of 43 carcasses were measured ranging in size from 49 cm FL to 83 cm FL (Appendix, Figure 7). Trapping records at RBDD indicate a cutoff length between adults and grilse salmon of 61 cm FL for all runs of salmon in the Sacramento River drainage. Using this RBDD criterion, 23% of the spring run were grilse and 77% were adult salmon, at least 3-years old. Given that an unknown percentage of spring run in Mill and Deer creeks exhibit a yearling life-history strategy, these fish may return at a different age and size than spring run fry which emigrate to the ocean within their first year. Therefore, a generalized cutoff length of 61cm may not reflect the actual age structure of SRCS in Mill and

Deer Creeks. Appendix, Figure 7 suggests that the cutoff length between two and three-year-old fish may be between 50 and 55cm FL. No attempt was made to further refine the age distribution of adult spring run for 1998. Sixty-seven percent of the carcasses identified were female and 33% were male. Due to the low sample size and the tendency for male salmon (grilse and adults) to swim away from the spawning areas before dying, this carcass data set may not reflect the actual age and sex composition of the population. DNA fin clips for genetic analysis were collected to aide researchers in characterizing Central Valley spring-run salmon population genetic structure and developing a loci to discriminate spring run from other Central Valley Chinook stocks. Collections were preserved using the Tris Buffer Method and sent to the Departments Salmon Stock Tissue Collection Archive. A total of 16 samples were collected in Mill Creek and 77 samples in Deer Creek.

Population Trend and Cohort Replacement Rate

For Mill Creek, the estimated 424 SRCS adults returning to spawn in 1998 represents a cohort replacement rate (CCR) of 1.3, when compared with the 320 spawners returning in 1995. Typically a CRR greater than 1.0 represents increasing cohort abundance. (In calculating CRR’s it is currently assumed adult escapement methodologies are comparable, all spawners return as 3-year-old fish, there is a 1:1 sex ratio in the population, and there is no variation in these factors between brood years. In fact, as explained in the previous paragraph, age structure and sex ratio for SRCS is only speculative at this time.) Table 1 shows the CCR’s for Mill Creek SRCS for the time periods 1957-1964, and 1990-1998. The 1998 population of 424 is still a significant decline from the counts of 3,500 salmon in the 1940's. In the 1990's counts have ranged from a low of 61 salmon in 1993 to a high of 844 in 1990 (Appendix, Figure 8).

For Deer Creek, the count of 1879 represents a CRR of 1.5, when compared with the 1295 spawners in 1995. This data represents an increase in cohort abundance. Table 2 shows the CCR's for Deer Creek spring-run salmon for the time periods 1990-1998. Counts in Deer Creek have been as high as 4,000 salmon in the 1940's. More recently in the 1990's, counts have ranged from a low of 209 salmon in 1992 to this year's high of 1,879 (Appendix, Figure 9).

TABLE 1. Mill Creek spring-run chinook salmon cohort replacement rates.

Cohort	Brood Year	Cohort Replacement Rate
1	1957	1203/1789=0.7
2	1958	2212/2967=0.7
3	1959	1580/2233=0.7
1	1960	2368/1203=2.0
2	1961	1245/2212=0.6
3	1962	1692/1580=1.1
1	1963	1315/2368=0.6
2	1964	1628/1245=1.3
1	1990	844/89=9.5
2	1991	319/572=0.6
3	1992	237/563=0.4
1	1993	61/844=0.1
2	1994	723/319=2.3
3	1995	320/237=1.4
1	1996	252/61=4.1
2	1997	202/723=0.3
3	1998	424/320=1.3

TABLE 2. Deer Creek spring-run chinook salmon cohort replacement rates.

Cohort	Brood Year	Cohort Replacement Rate
1	1990	458/200=2.3
2	1991	448/371=1.2
3	1992	209/77=2.7
1	1993	259/458=0.6
2	1994	485/448=1.1
3	1995	1295/209=6.2
1	1996	614/259=2.4
2	1997	466/485=1.0
3	1998	1879/1295=1.5

Conditions for Adult SRCS Holding and Spawning

Immature adult SRCS hold in the higher elevations of Mill and Deer creeks from the time of spring migration until the onset of fall spawning–approximately May through September. Temperature records in the holding and spawning habitat are presented here for the purpose of documenting the actual temperature regimes wild salmon are holding and spawning in. According to Hinz (1959), the survival of adult fish can be reduced when holding in water temperatures warmer than 59°F. Additionally, prolonged exposure of female salmon to water temperatures between 60°F and 62°F can reduce egg viability up to 30%. In Appendix, Figures 10 and 11, average daily mean water temperatures at select locations are graphed during adult salmon holding periods in Mill and Deer creeks, respectively. The maximum average daily temperature threshold for normal egg viability is shown as 59°F.

In Mill Creek at Hwy-36, the water temperature exceeded the 59°F threshold on three days between 3 and 7 September. The maximum temperature recorded was 60.5°F. At Hole-in-the Ground, water temperature remained at or below the 59°F throughout the adult salmon holding period. At Black Rock the average daily water temperature exceeded the threshold for 25 days between 25 July and 8 September. The maximum recorded average daily temperature was 63°F on 14 August. The water temperature at Little Mill remained above 59°F after 5 July. The maximum recorded water temperature was 69.5°F on 14 August. Since the holding distribution of adult salmon in Mill Creek was not monitored in 1998, no speculations can be made about the effects of elevated water temperatures on adult salmon survival or egg viability.

In Deer Creek, 10% of the SRCS population counted in 1998 was holding in the Upper Falls and A-Line reaches (Harvey Arrison, 1998b). Average daily water temperatures at Upper Falls exceeded 59°F on only one day, 25 July. In the A-line holding area, the water temperature rose above 59E for a total of 21 days between 21 July and 7 September. The maximum average daily water temperature during this time period was 61.9°F. Forty-nine percent of holding SRCS adults occurred between Polk Springs to Beaver Creek in 1998. The nearest temperature recording station is downstream at Ponderosa Way. Water temperatures at Ponderosa Way remained above 59°F from 2 July to 18 September. The highest daily average temperature during this time period was 67.1°F recorded on 14 August. No temperature records are available below Ponderosa Way for these time periods. Therefore, no conclusion can be made about the maximum water temperatures for the 30% of the salmon population holding between Ponderosa Way and Dillon Cove. Eighty percent of adult SRCS holding in Deer Creek in 1998 were in areas where the daily average water temperatures were above the referenced optimal level of 59°F. No temperature studies have been made on these creeks to investigate possible thermal stratification or spring influences and whether this may affect salmon distribution. It is unknown why adult salmon were concentrated in areas with water temperatures up to 8°F warmer than holding pools at higher elevations. In 1998 less than 1% of the population held in water temperatures considered optimal for survival. It is also unknown whether these higher temperatures affected spawning success or salmon egg viability.

Current literature suggests that the upper temperature tolerance for spawning adult salmon, without destroying egg viability, is 57°F (Reiser and Bjorn, 1979). When water temperatures exceed 57.5°F, up to 80% salmon egg and fry losses can occur (Healey, 1977). In Mill Creek the average daily water temperatures dropped below the 57°F threshold first in the Hole-in-the-Ground area on 8 September (Appendix, Figure 12). In the Black Rock and Hwy-36 reaches, temperatures decreased to below the threshold on 17 September. Areas of Mill Creek near Little Mill Creeks' confluence cooled down 3 October. Spawning surveys in 1998 did not begin until 21 September. It is unknown whether spawning activities began prior to water temperatures decreasing to below the threshold level. Water temperatures were below 57°F during the spawning surveys.

In Deer Creek temperatures dropped below the 57°F threshold first at A-Line on 10 September and then on 19 September for Ponderosa Way (Appendix, Figure 13). No water temperature records are available during SRCS spawning times in 1998 for the Upper Falls and Apperson Cow Camp Areas. In 1998, weekly surveys of indexed areas to determine the onset, peak and termination of spawning were not made, and therefore it is unknown whether spawning activities began prior to a decrease in water temperatures. The spawning distribution surveys were made the week of 13 October.

Egg Incubation, Hatching and Fry Emergence

Daily water temperature records are used to estimate the length of time from spawning for the eggs to hatch and fry to emerge from the gravels. In Mill Creek, water temperature records from Hole-in-the-Ground, Black Rock and below the Little Mill confluence are usually used for emergence timing studies. In 1998, complete water temperature records are only available for the Black Rock area of Mill Creek. In Deer Creek water temperature records from Upper Falls, A-Line Bridge, Ponderosa Way and Apperson Cow Camp are usually used for the emergence studies. This year there are no complete temperature data sets to use in predicting fry emergence in Deer Creek.

To predict an estimated time of fry emergence, daily temperature units (DTU) were calculated from the water temperature records on each creek. A DTU is defined as the average daily water temperature (in Fahrenheit) minus 32. From the time of egg fertilization, a cumulative total of 1,550 DTU's is required for the egg to hatch and the fry to emerge (Armor, 1991 in CDFG, 1998). Based on the number of redds and live fish seen on each of three spawning surveys, the week of 22 September appeared to represent the peak of spawning activities in the Black Rock area of Mill Creek. Using this peak spawning date, the calculated date of peak emergence of fry in the Black Rock area was 28 January1999 (Table 3). The time lapse between the onset and termination of spawning (generally late August through the end of October) can last up to eight weeks. This can lead to a great deal of variability in the onset and termination of fry emergence. Since weekly surveys to determine the onset and termination of spawning were not made in 1998, the earliest and latest expected emergence of fry is not estimated for either Mill or Deer Creek.

In Mill Creek, biweekly electrofishing surveys to detect 98BY fry emergence began 17 December at Black Rock. The first emergent fry was captured on 19 February, 21 days after calculated emergence. The first group of fry (>5 fish) was captured on 16 March, 46 days after calculated emergence (Table 4). In order to minimize damage to eggs and pre-emergent fry, electrofishing surveys are made in edge water habitats away from known redd locations. This may explain the time lapse between calculated emergence from the redd and emergent fry captured in the edge water habitat.

In Deer Creek, the first survey to detect 98BY fry was on 23 December at Ponderosa Way. One emergent fry was captured. The first group of fry (>5 fish) was observed on 4 January. At the A-line Bridge, the first emergent fry was captured on 26 February, and the first group of fry (>5 fish) was captured one month later on 24 March. Since there are no complete temperature data sets in Deer Creek for the winter of 1998, observed emergence cannot be compared with calculated emergence.

TABLE 3. Mean daily water temperatures in Mill Creek at lack Rock. Estimated time of fry emergence based on September 22 peak of spawning and calculated from daily temperature units (DTU).

Day	SEP 98 mean	TU	CUM TU	OCT 98 mean	TU	CUM TU	NOV 98 mean	TU	CUM TU	DEC 98 mean	TU	CUM TU	JAN 99 mean	TU	CUM TU
1	60.0			54.2	22.2	207.8	46.7	14.7	702.2	43.6	11.6	1042.2	40.4	8.4	1311
2	59.9			53.7	21.7	229.5	44.6	12.6	714.8	44.4	12.4	1054.6	40.4	8.4	1319
3	60.2			51.3	19.3	248.8	46.1	14.1	728.9	43.7	11.7	1066.3	40.4	8.4	1328
4	61.2			48.6	16.6	265.4	45.8	13.8	742.7	40.4	8.4	1074.7	40	8.0	1336
5	60.5			49.3	17.3	282.7	45.8	13.8	756.5	37.9	5.9	1080.6	40.1	8.1	1344
6	60.2			49.7	17.7	300.4	42.9	10.9	767.4	37.0	5.0	1085.6	40.6	8.6	1352
7	61.4			49.5	17.5	317.9	42.4	10.4	777.8	37.7	5.7	1091.3	39.8	7.8	1360
8	60.1			50.6	18.6	336.5	41.3	9.3	787.1	40.0	8.0	1099.3	39.9	7.9	1368
9	58.1			49.0	17.0	353.5	40.4	8.4	795.5	38.5	6.5	1105.8	40.5	8.5	1376
10	55.3			46.9	14.9	368.4	41.7	9.7	805.2	39.1	7.1	1112.9	40.7	8.7	1385
11	56.0			1/ 46.0	14.0	382.4	41.2	9.2	814.4	40.8	8.8	1121.7	40.4	8.4	1394
12	57.4			48.6	16.6	399.0	41.9	9.9	824.3	42.5	10.5	1132.2	40.1	8.1	1402
13	57.5			48.6	16.6	415.6	42.8	10.8	835.1	43.2	11.2	1143.4	41.6	9.6	1411
14	57.7			48.6	16.6	432.2	42.5	10.5	845.6	41.8	9.8	1153.2	42.1	10.1	1421
15	58.1			48.6	16.6	448.8	44.0	12.0	857.6	40.8	8.8	1162.0	44.2	12.2	1434
16	57.3			48.6	16.6	465.4	44.2	12.2	869.8	2/ 40.8	8.8	1170.8	44.3	12.3	1446
17	56.0			48.6	16.6	482.0	44.0	12.0	881.8	40.8	8.8	1179.6	43.5	11.5	1457
18	54.0			48.6	16.6	498.6	42.5	10.5	892.3	40.8	8.8	1188.4	43.3	11.3	1469
19	53.4			48.6	16.6	515.2	41.7	9.7	902.0	40.8	8.8	1197.2	42.7	10.7	1479
20	54.0			48.6	16.6	531.8	42.1	10.1	912.1	40.8	8.8	1206.0	42.3	10.3	1490
21	53.2			48.6	16.6	548.4	44.9	12.9	925.0	40.8	8.8	1214.8	41.6	9.6	1499
22	52.9	20.9	20.9	47.6	15.6	564.0	44.8	12.8	937.8	40.8	8.8	1223.6	41.8	9.8	1509
23	53.5	21.5	42.4	47.3	15.3	579.3	45.6	13.6	951.4	40.8	8.8	1232.4	40.1	8.1	1517
24	53.9	21.9	64.3	47.4	15.4	594.7	43.2	11.2	962.6	40.8	8.8	1241.2	38.7	6.7	1524
25	53.5	21.5	85.8	46.9	14.9	609.6	43.4	11.4	974.0	40.8	8.8	1250.0	38.9	6.9	1531
26	52.7	20.7	106.5	47.3	15.3	624.9	43.8	11.8	985.8	40.8	8.8	1258.8	40.8	8.8	1540
27	50.2	18.2	124.7	47.6	15.6	640.5	44.1	12.1	997.9	40.8	8.8	1267.6	39.5	7.5	1547
28	50.4	18.4	143.1	49.5	17.5	658.0	43.8	11.8	1009.7	40.8	8.8	1276.4	3/ 39.6	7.6	**1555**
29	52.8	20.8	163.9	48.4	16.4	674.4	41.1	9.1	1018.8	40.8	8.8	1285.2	38.7	6.7	1561
30	53.7	21.7	185.6	45.1	13.1	687.5	43.8	11.8	1030.6	40.8	8.8	1294.0	38.6	6.6	1568
31				44.4	12.4	699.9				40.8	8.8	1302.8	39.6	7.6	1576

1/ No data 10/12/-20/99 monthly avg used

2/ No data 2/15-31/99 monthly avg used.

TABLE 4. Actual and calculated emergence of spring-run chinook salmon fry in Mill and Deer creeks from the estimated peak of spawning based on TU's. (Table 3) a/

	Mill Creek			Deer Creek		
	Hole-in-Ground	Black Rock	Little Mill	A-line	Ponderosa Way	Apperson
1st Observed Emergence	no surveys	2/19/99	no surveys	02/26/99	12/23/98	no surveys
1st Group Emergence n>5	no surveys	3/16/99	no surveys	03/24/99	1/4/99	no surveys
Calculated Emergence	incomplete records	01/28/99	incomplete records	incomplete records	incomplete records	incomplete records

a/ Due to low sampling intensity and the duration of time between the onset and termination of spawning, this data may not reflect the earliest dates of actual and calculated emergence.

SRCS Juvenile Rearing

In Mill Creek headwaters, 1998BY SRCS were sampled in bimonthly electrofishing samples from 19 February, 1999 through 31 March, 2000. A total of 170 juveniles were captured ranging in size from 33 mm FL to 111 mm FL (Table 5). In Deer Creek headwaters, 1998 BY SRCS were sampled from 23 December, 1998 through 7 February, 2000. A total of 271 juveniles were captured ranging in size from 32 mm FL to 78 mm FL (Table 6.) Combining Mill and Deer Creek rearing data, SRCS emerged at approximately 32 mm FL and grew to at least 111 mm FL over a 15-month period. Recently emerged fry, (33-39mmFL), continued to be sampled through 15 April, 1999 in Mill Creek, (Appendix, Figures 14 and 15), and 15 May, 1999 in Deer Creek, (Appendix, Figures 16 and 17). This apparent "continual emergence" may be a result of the range in spawning times resulting in a constant recruitment of smaller fish into the sampling site, or reduced growth of weaker fish. Once fish reached 70-80 mm FL in both creeks they appeared to either migrate out of the sample reaches or effectively escape the sampling gear (Appendix, Figures 16-19). Due to the gear selectivity associated with electrofishing, the actual maximum obtained growth may be larger than the observed maximum growth. In future years additional sampling techniques will be employed to get a more representative sample of rearing SRCS length distribution. From this data we cannot predict what proportion of the 1998BY emigrated as fry or reared over summer and emigrated as yearlings. Also, distribution of rearing juveniles in each watershed thru time has not been researched.

Growth Rates for rearing SRCS

Growth rates are not calculated for SRCS juveniles rearing in these creeks. In order to calculate a growth rate, sufficient numbers would need to be tagged with unique marks and consistently recaptured throughout the rearing period. This was attempted in 1996. All juveniles sampled during biweekly surveys in Mill and Deer Creek were Coded-Wire-Tagged (CWT'ed). A total of 157 SRCS was CWT'ed in Mill Creek, and a total of 782 was CWT'ed in Deer Creek. None of these tagged fish were recaptured on subsequent juvenile or adult surveys. In general, too few juveniles are captured to get recoveries on tagged fish. Calculated growth rates for chinook salmon rearing in the Upper Sacramento River averaged 0.33 mm/day and ranged from 0.26 to 0.40 mm/day, (Kjelson et.al., 1982). Growth rates for chinook salmon from two different brood years in Butte Creek (including spring run and fall run) were calculated at 0.77 mm/d (range 0.45 to 1.02mm/d) and 0.2 mm/d (range 0.09 to 0.32 mm/d) respectively, (Hill, 1999). SRCS in Butte Creek are incubating and rearing at different elevations and water temperatures than Mill and Deer Creek which may influence growth rates.

TABLE 5. Bimonthly electrofishing catch summary of spring-run Chinook salmon rearing in Mill Creek at Hole-in-the-Ground and Black Rock from December 1998 through March 2000. Only 1998 brood year fish are reported.

Capture Period	Mean FL (mm)	Standard Deviation	Range min (mm)	FL max (mm)	Total Number Captured
12/16/98-12/31/98					0
01/01/99-01/15/99					0
01/16/99-01/31/99					0
02/01/99-02/15/99					0
02/16/99-02/28/99	35	0.7	34	35	2
03/01/99-03/15/99	36	2.6	34	40	6
03/16/99-03/31/99	38	2.6	33	43	28
04/01/99-04/15/99	39	5.8	34	53	16
04/16/99-04/30/99	42	5.8	35	54	40
05/01/99-05/15/99	46	7.1	38	62	29
05/16/99-05/31/99	52	6.1	43	64	16
06/01/99-06/15/99	59	5.6	47	69	10
06/16/99-06/30/99	70	6.5	59	81	12
07/01/99-07/15/99	62	4.6	57	70	7
07/16/99-07/31/99					0
08/01/99-08/15/99					no surveys
08/16/99-08/31/99					no surveys
09/01/99-09/15/99					no surveys
09/16/99-09/30/99					0
10/01/99-10/15/99	No surveys between October 1, 1999 and December 31, 1999				
10/16/99-10/31/99					
11/01/99-11/15/99					
11/16/99-11/30/99					
12/01/99-12/15/99					
12/16/99-12/31/99					
01/01/00-01/15/00	108	4.2	105	111	2
01/16/00-01/31/00					0
02/01/00-02/15/00	109		109	109	1
02/16/00-02/29/00					0
03/01/00-03/15/00					0
03/16/00-03/31/00	107		107	107	1

TABLE 6. Bimonthly electrofishing catch summary of spring-run chinook salmon rearing in Deer Creek at A-Line Bridge and Ponderosa Way from December 1998 through February 200. Only 1998 brood year fish are reported.

Capture Period	Mean FL (mm)	Standard Deviation	Range min (mm)	FL max (mm)	Total Number Captured
12/16/98-12/31/98	35		35	35	1
01/01/99-01/15/99	35	1.1	34	37	27
01/16/99-01/31/99					0
02/01/99-02/15/99	35	0.9	33	36	17
02/16/99-02/28/99	36	0.6	35	36	3
03/01/99-03/15/99	38	1	37	39	4
03/16/99-03/31/99	36	2.8	33	46	27
04/01/99-04/15/99	35	1.6	32	39	29
04/16/99-04/30/99	36	2	32	44	89
05/01/99-05/15/99	37	2.2	34	42	14
05/16/99-05/31/99	43	7.6	36	52	4
06/01/99-06/15/99	53	4.9	41	61	15
06/16/99-06/30/99	58	5.7	47	71	30
07/01/99-07/15/99	72	3.5	67	76	7
07/16/99-07/31/99	70	8	62	78	3
No data collected between August 1, 1999 and December 7, 1999					
08/01/99-08/15/99					
08/16/99-08/31/99					
09/01/99-09/15/99					
09/16/99-09/30/99					
10/01/99-10/15/99					
10/16/99-10/31/99					
11/01/99-11/15/99					
11/16/99-11/30/99					
12/01/99-12/15/99					0
12/16/99-12/31/99					no surveys
01/01/00-01/15/00					0
01/16/00-01/31/00					0
02/01/00-02/15/00	73		73	73	1

SRCS Fry and Yearling Emigration

Rotary screw traps are used to sample fry and yearling chinook salmon outmigration in each creek. The purpose of this sampling is to determine the relative size at outmigration and the timing of outmigration. Abundance estimates of SRCS emigrants are not made due to the difficulties of obtaining trap efficiency estimates during peak emigration periods (i.e., high flow events, debris, trap removal, and run separation). Also, recaptures from the small numbers of wild fish captured in the trap may not be obtainable during normal flow events.

The screw traps in each creek are placed within the fall-run chinook salmon (FRCS) spawning habitat. Although fall run spawn later in the season than spring run, FRCS fry emergence and emigration timing may be similar to SRCS due to warmer water temperatures during egg incubation in fall run spawning areas. Therefore, chinook fry captured in the rotary screw trap are not identified to run. All yearling-sized chinook salmon captured in the traps are assumed to be SRCS.

In Mill Creek, the rotary screw trap was fished from 26 October 1998 through 31 of January 1999. The trap was not fished from 1 February 1999 through 7 October 1999. Trapping resumed 8 October 1999 and continued through 30 June 2000. A total of 485, 1998 BY SRCS and FRCS fry, and 50, 1998 BY SRCS yearlings were trapped during these time periods (Table 7 and Appendix, Figures 18 and 19). Fry ranged in size from 32 to 41 mm FL and yearlings ranged in size from 68 to 140 mm FL. The first 1998 BY fry outmigrant was captured on 16 November 1998. It is unknown when fry outmigration ended since the trap was removed in January 1999. The first yearling outmigrant was trapped on 10 October 1999. Yearlings continued to be captured through 1 May 2000.

For the 1998 BY outmigration sampling period there were two periods of increased migration. These peak periods of migration were associated with increased flow and turbidity (Appendix, Figures 20 and 21). From 10 January 1999 through 23 January 1999, 94% of the total trap catch for the fall sampling period emigrated from Mill Creek. Peak average weekly flow was 599 cfs and peak average weekly turbidity was 23 ntu's. From 9 January 2000 through 12 February 2000, 81% of the total trap catch for the spring of 2000 sampling period emigrated. Peak average weekly flow was 596 cfs and peak average turbidity was 18 cfs. (Actual peak flows and turbidities may have been higher during these time periods but the trap was removed at flows exceeding 1000 cfs).

TABLE 7. Size statistics and bimonthly catch of spring-run and fall-run chinook salmon fry and spring-run chinook salmon yearlings captured in the Mill Creek rotary screw trap. Only 1998 brood year salmon are reported.

Capture Period	Mean FL (mm)	Standard Deviation	Range FL min (mm)	max (mm)	Total Number Captured
11/16/98-11/30/98	34		34	34	1
12/01/98-12/15/98					0
12/16/98-12/31/98	35	1.4	33	37	6
01/01/99-01/15/99	35	1.2	32	39	132
01/16/99-01/31/99	36	1.4	33	41	346
02/01/99-02/15/99	no sampling February 1999 thru September 1999				
02/16/99-02/28/99					
03/01/99-03/15/99					
03/16/99-03/31/99					
04/01/99-04/15/99					
04/16/99-04/30/99					
05/01/99-05/15/99					
05/16/99-05/31/99					
06/01/99-06/15/99					
06/16/99-06/30/99					
07/01/99-07/15/99					
07/16/99-07/31/99					
08/01/99-08/15/99					
08/16/99-08/31/99					
09/01/99-09/15/99					
09/16/99-09/30/99					
10/01/99-10/15/99	111	1.5	109	112	3
10/16/99-10/31/99	103	18.6	68	140	15
11/01/99-11/15/99					0
11/16/99-11/30/99					0
12/01/99-12/15/99	102	8.4	91	110	5
12/16/99-12/31/99					0
01/01/00-01/15/00	95	6.4	90	99	2
01/16/00-01/31/00	108	16.3	87	131	6
02/01/00-02/15/00	103	8.6	94	113	5
02/16/00-02/29/00	107	3	104	110	3
03/01/00-03/15/00	113	7.5	103	122	5
03/16/00-03/31/00	99	4.9	95	102	2
04/01/00-04/15/00	131	1.2	130	132	3
04/16/00-04/30/00					0
05/01/00-05/15/00	128		128	128	1

In Deer Creek the rotary screw trap was fished from 26 October 1998 through 31 January 1999. The trap was not fished from 1 February 1999 through 14 October 1999. Trapping was resumed on 15 October 1999 and continued through 30 June 2000. A total of 1,052, 1998 BY SRCS and FRCS fry, and 120, 1998 BY SRCS yearlings were trapped during these time periods (Table 8 and Appendix, Figures 22 and 23). Fry ranged in size from 31 to 41 mm FL and yearlings ranged in size from 73 to 158 mm FL. The first 1998 BY fry was captured on 25 November 1998. It is unknown when fry outmigration ended since the trap was removed in January 1999. The first yearling outmigrant was trapped on 16 October 1999. Yearlings continued to be captured in the trap through 23 April 2000.

For the 1998 BY outmigration sampling period in Deer Creek there were two periods of increased migration. The first peak occurred 17 January through 30 January 1999. Eighty-seven percent of the total trap catch for the fall outmigration period emigrated from Deer Creek (Appendix, Figures 24 and 25). Peak average weekly flow was 526 cfs and peak average weekly turbidity was 8 ntu's. From 23 January through 12 February 2000, 41% of the trap catch for the spring sampling period emigrated. Peak average weekly flow and turbidity was 688 cfs and 7 ntu's, respectively. There were two other peak flow periods when no increase in emigration was recorded. This occurred the week of 29 November 1998 and the month of February 2000. Peak flows were 1,000 cfs and 1,500 cfs, respectively. Two additional peak turbidity periods occurred the weeks of 29 November 1998 and 24 October 1999. Removal of the traps restricts our ability to document emigration during these peak events.

Water Temperatures at Emigration

The upper lethal water temperature level for emigrating salmon is determined in part by acclimation temperatures. Higher acclimation temperatures produce higher tolerated temperature until an upper lethal limit is reached. For fish acclimated to 60EF the upper lethal limit is 70°F and for fish acclimated to 70°F the upper lethal limit is 76.8°F (Orsi, 1971; in Boles, 1988). For the fall 1999 yearling SRCS outmigration period in Mill Creek water temperature did not exceed 61°F at the trap site, (unpublished data). Water temperature data has not been compiled for the spring 2000 outmigration period. In Deer Creek, water temperatures at the trap site did not exceed 63.6°F during fall 1999 yearling SRCS emigration periods. Maximum water temperatures for the spring 2000 outmigration period at the trap site did not exceed 65°F.

Adult salmon are entering and juveniles are emigrating from these creeks during the early fall and late spring when water temperatures and flows are sub-optimal. Therefore, management of water temperature and flow for the less thermally tolerant and larger adults should automatically afford thermal protection and passage for juveniles.

TABLE 8. Size statistics and bimonthly catch of spring-run and fall-run chinook salmon fry and spring-run chinook salmon yearlings captured in the Deer Creek rotary screw trap. Only 1998 brood year fish are reported.

Capture Period	Mean FL (mm)	Standard Deviation	Range FL min (mm)	max (mm)	Total Number Captured
11/16/98-11/30/98	33	1	32	34	3
12/01/98-12/15/98	34	1.3	30	37	77
12/16/98-12/31/98	35	2.5	31	38	74
01/01/99-01/15/99	35	1.1	33	39	241
01/16/99-01/31/99	36	1.4	33	41	657
02/01/99-02/15/99	no sampling February 1, 1999 through October 15, 1999				
02/16/99-02/28/99					
03/01/99-03/15/99					
03/16/99-03/31/99					
04/01/99-04/15/99					
04/16/99-04/30/99					
05/01/99-05/15/99					
05/16/99-05/31/99					
06/01/99-06/15/99					
06/16/99-06/30/99					
07/01/99-07/15/99					
07/16/99-07/31/99					
08/01/99-08/15/99					
08/16/99-08/31/99					
09/01/99-09/15/99					
09/16/99-09/30/99					
10/01/99-10/15/99					
10/16/99-10/31/99	112	18.2	74	158	63
11/01/99-11/15/99	104	14.6	80	124	13
11/16/99-11/30/99	99	14.1	73	119	14
12/01/99-12/15/99					0
12/16/99-12/31/99	103	12.3	91	114	2
01/01/00-01/15/00	99		99	99	1
01/16/00-01/31/00	103	11.3	87	125	13
02/01/00-02/15/00	85	0	85	85	2
02/16/00-02/29/00	119		119	119	1
03/01/00-03/15/00	104	10.4	88	118	7
03/16/00-03/31/00	112		112	112	1
04/01/00-04/15/00	100	2.1	98	101	2
04/16/00-04/30/00	104		104	104	1

Condition Factors

One nonlethal method of determining the onset of smoltification in the field is to record the condition factor of outmigrants. (A condition factor, (K)), is a length-weight ratio calculated as: $K=W/L^3$, where W=weight in grams and L = length in millimeters. This ratio decreases as a fish loses body fat). Smolts weigh less and exhibit a lower length to weight ratio than do parr (Wedemeyer et. al. 1980). This season the measurement of the length to weight ratio was recorded throughout the season to determine if a drop in body weight occurred. In Mill Creek, the condition factor fluctuated between .00046 and .00029 (Appendix, Figure 26). The sample size is too small (n=24) to determine if a significant drop in body weight occurred during emigration. In Deer Creek the condition factor fluctuated between .00042 and .00037 (Appendix, Figure 27) with no apparent decrease in through time. The size selectivity of the screw trap may not represent the actual population of SRCS outmigrants. For example if the larger outmigrants or those fish in earlier stages of smoltification are able to avoid the trap, a drop in condition factors may not be apparent.

Real-time Delta Monitoring

Real-time monitoring of yearling SRCS emigration in Mill and Deer creeks is used in evaluating the distribution and movement of SRCS outmigrants through the Sacramento River and Sacramento-San Joaquin Delta. With the designation of SRCS as a candidate species under CESA in 1997, the Department and CALFED agencies established a SRCS Protection Plan (Spring-run Plan). The Spring-run Plan utilizes daily rotary screw trap data and measurement of environmental parameters (flow, turbidity), to identify when juvenile spring-run are likely entering the Delta. Once yearling salmon are detected in Mill, Deer and Butte creeks, operational responses are made to avoid or minimize the effects of the State Water Project and Central Valley Project facilities operations on juvenile salmon survival through the Delta.

RECOMMENDATIONS

Real-time monitoring of adult migration, water temperatures and water attraction flows in Mill and Deer creeks is needed for coordination between instream flows for fish and water management during periods of adult migration. The real-time monitoring of yearling spring-run chinook emigration should continue in order to provide data in evaluating salmon occurrence, distribution and movement through the Sacramento River and Sacramento-San Joaquin estuary. Emigration monitoring should be expanded to include the months of February through June when spring- and fall-run fry are migrating from each creek. Sacramento-San Joaquin flow standards and water project facilities operational criteria should be evaluated for these spring periods of SRCS fry outmigration.

Currently, the ability to identify the impacts of harvest on listed salmon, the potential of hybridization in habitats accessible to multiple runs of salmon, and impacts of water management on juvenile salmon is confounded by the inability to separate runs of chinook salmon based solely on phenotypical characteristics, life history differences and size criteria. Funding and staffing for genetic tissue and otolith collection and analysis on spring-run stocks has not been adequately coordinated. A comprehensive assessment of genetic population structure is needed in order to define a genetic baseline for stock identification.

There are no established minimum flow standards in Mill or Deer creeks to ensure adequate attraction and transport flow and temperatures from the Sacramento River upstream past diversions points in the valley floor. Currently there are no systematic surveys scheduled during the months of April thru June to monitor and document migration timing, fish passage, critical riffles, adult stranding or thermal barriers. There is a need to conduct systematic monitoring of the above listed parameters as a basis for establishing real-time minimum flow releases in each creek during the months of April-June. If it is determined that the instream flow requirements for migrating salmon exceeds available bypass flows below diversion points, alternate means of meeting irrigation demands will need to be identified.

The only spring-run population within the Central Valley being Coded Wire Tagged (CWT'ed) is Butte Creek. CWT returns are used in monitoring juvenile movement through the Sacramento San-Joaquin Delta, ocean movement and harvest, straying of adults and age structure of adult populations. A pilot CWT study was made in Mill and Deer creeks in 1995, but after extensive sampling effort, less than 1,000 fish were tagged. When population levels increase and at least 50,000 juveniles can be tagged in each creek, this project should resume a CWT'ing program.

In the Sacramento-San Joaquin River system the accepted method to separate captured juvenile chinook salmon into their respective runs is based on length criteria. This length criteria assumes that since the four runs of salmon spawn at different times, respective juveniles can be identified based on length, and length thru time can be estimated using a calculated growth curve (Fisher, 1992). This growth curve and length criteria were developed prior to our current knowledge on spring run life history and prior to current juvenile monitoring in spring run tributaries. As a result, the growth curve currently in use assumes an earlier than actual spawning time and an increased hatching and growth rate. Therefore, fish being trapped in rotary screw traps throughout the Central Valley are misidentified as true spring-run and true spring-run are being misidentified as winter- and late-fall run. In future brood year reports, Mill and Deer creek spring run will be compared to the current growth chart being used in the Central Valley. A new growth curve and length criteria should be developed for stream-type tributary SRCS.

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